
University of Southern California
Center for SoftwareEngineering

CeBASE

# High Dependability Computing in a Competitive World

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# HDC in a Competitive World

- The economics of IT competition and dependability
- Software Dependability Opportunity Tree
  - Decreasing defects
  - Decreasing defect impact
  - Continuous improvement
- Conclusions and References

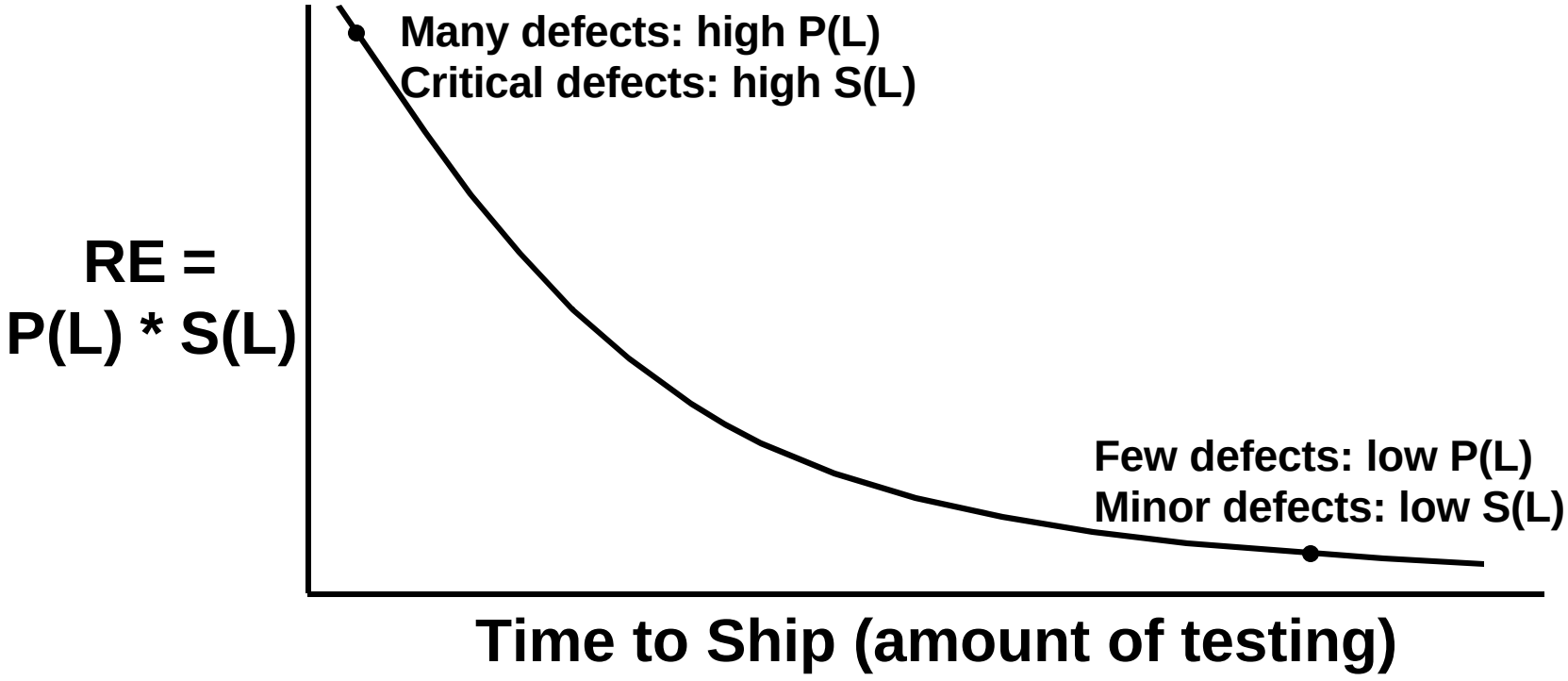
# Competing on Schedule and Quality
## - A risk analysis approach

- Risk Exposure RE = Prob (Loss) * Size (Loss)
  - "Loss" – financial; reputation; future prospects, …
- For multiple sources of loss:

$$RE = \sum_{sources} [Prob(Loss) * Size(Loss)]_{source}$$

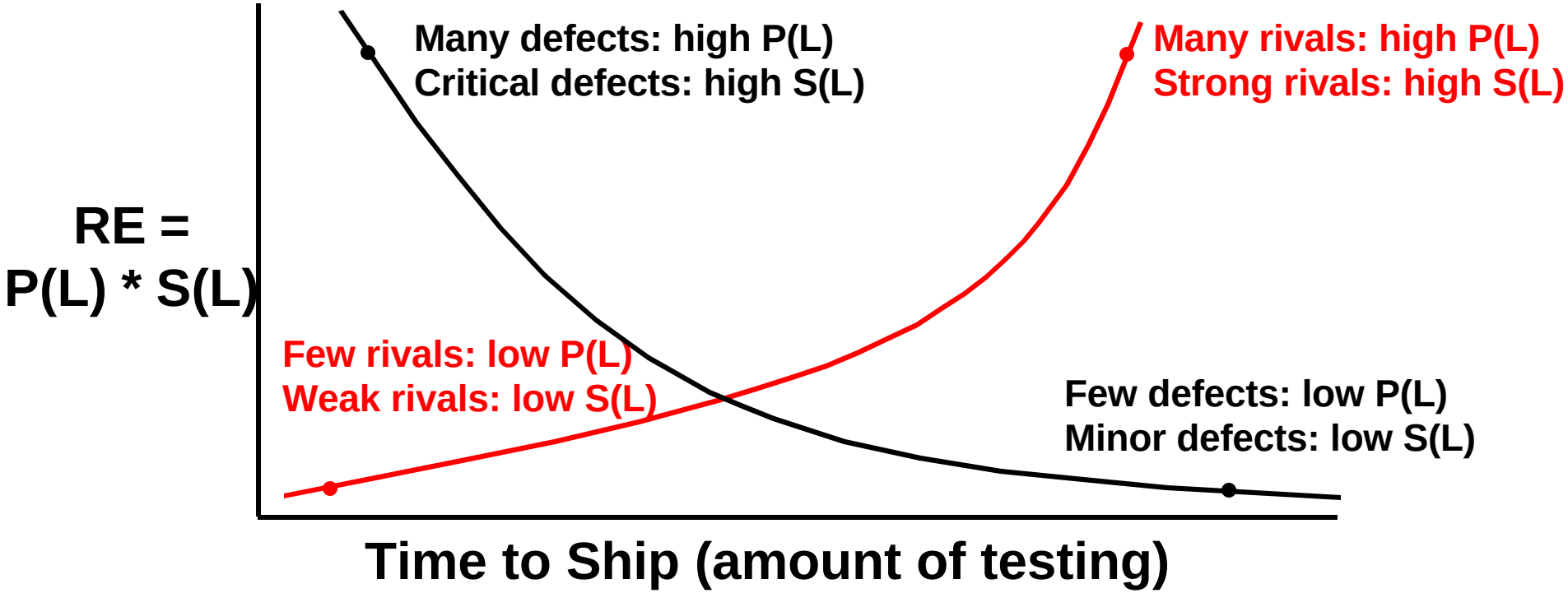
# Example RE Profile: Time to Ship

## - Loss due to unacceptable dependability



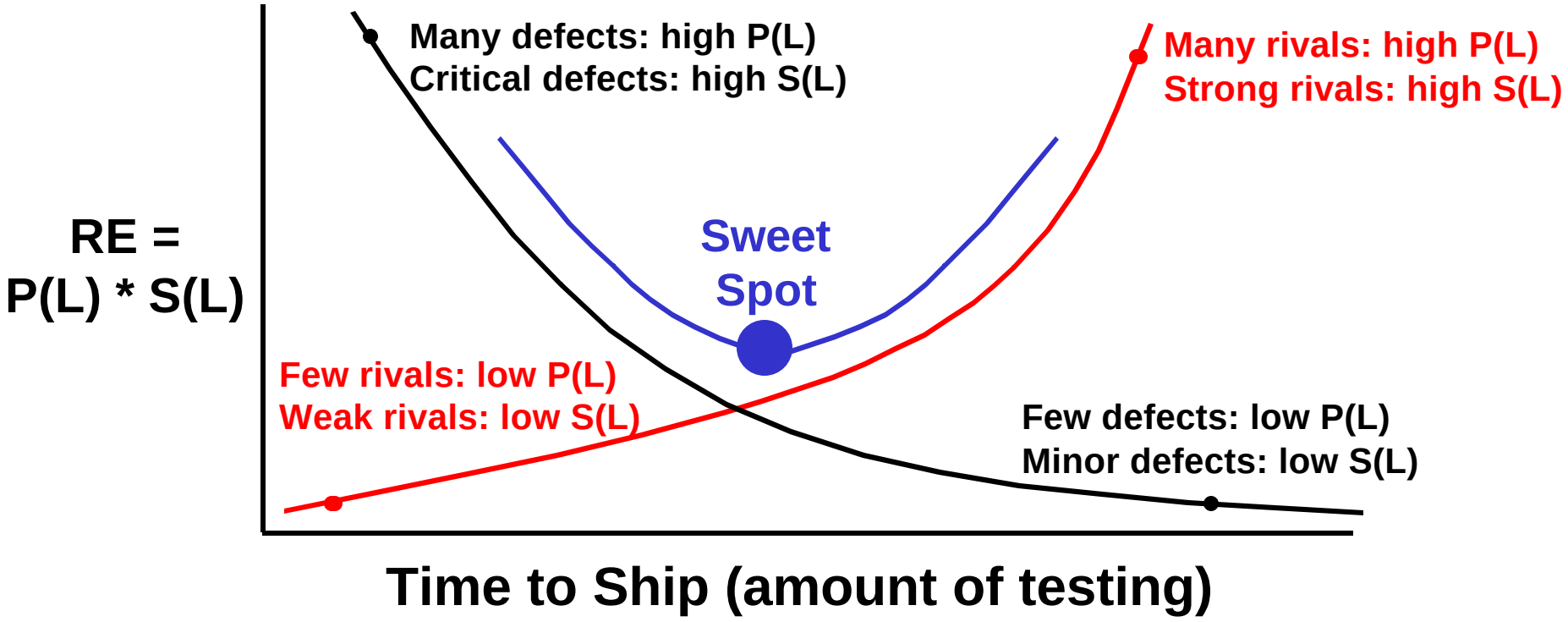
# Example RE Profile: Time to Ship

- Loss due to unacceptable dependability
  - Loss due to market share erosion



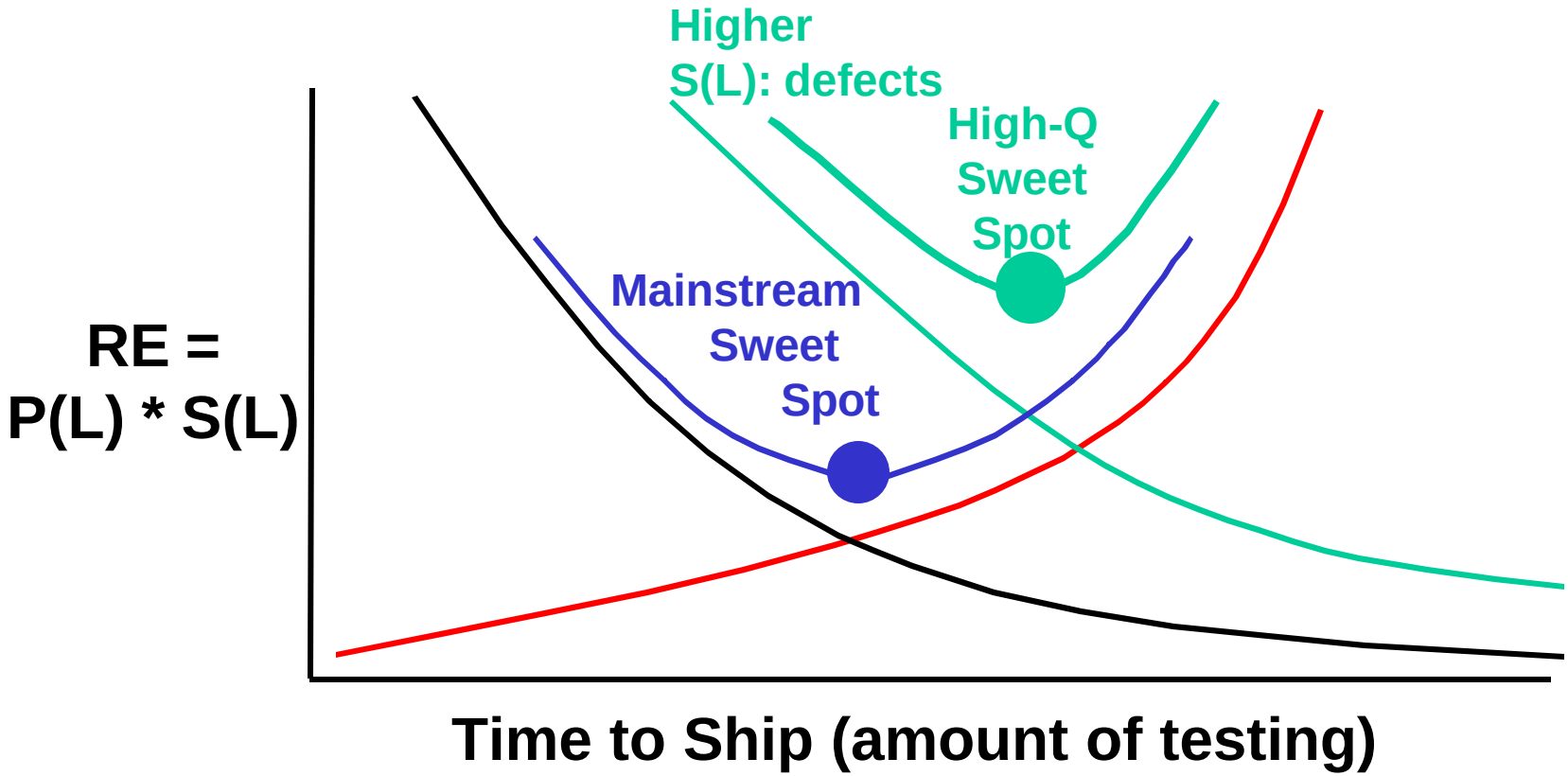
# Example RE Profile: Time to Ship

## - Sum of Risk Exposures

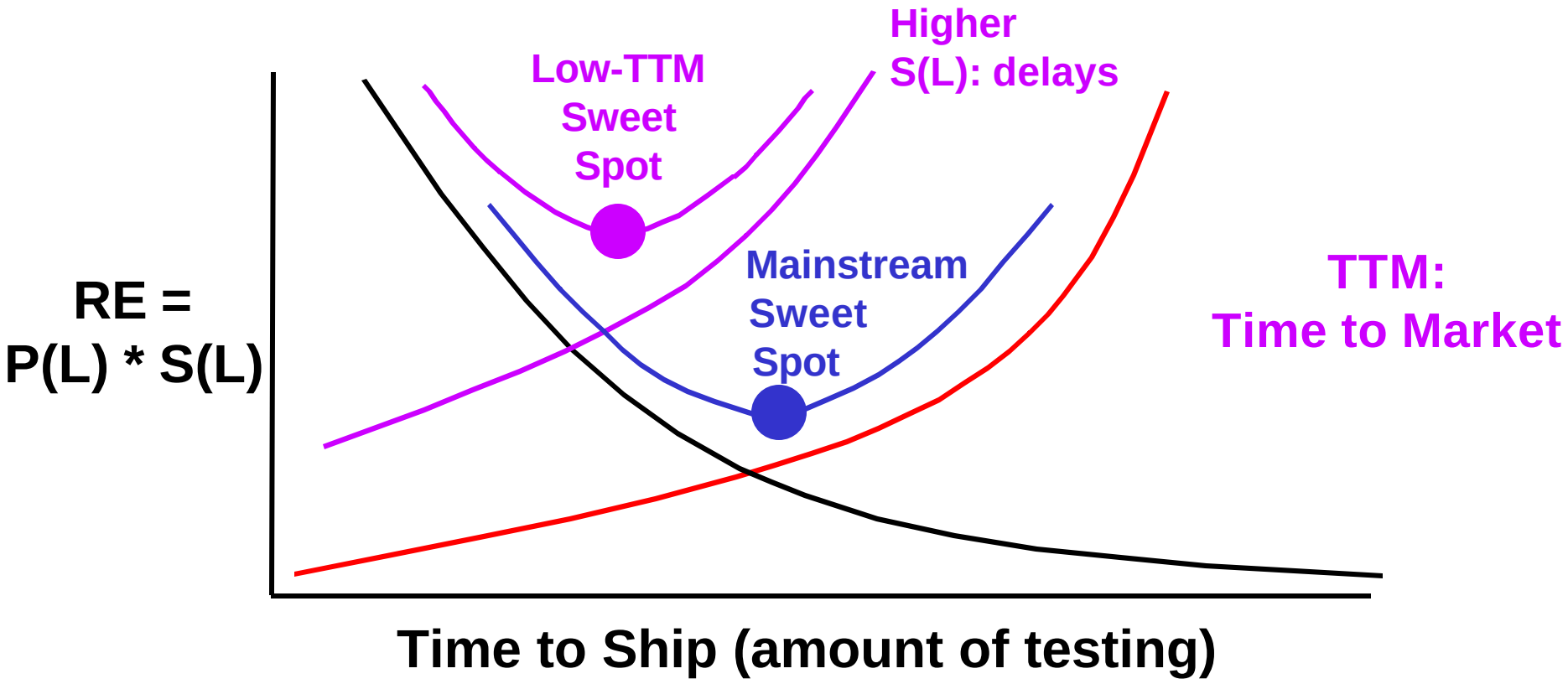


# Comparative RE Profile:

## Safety-Critical System



# Comparative RE Profile: Internet Startup

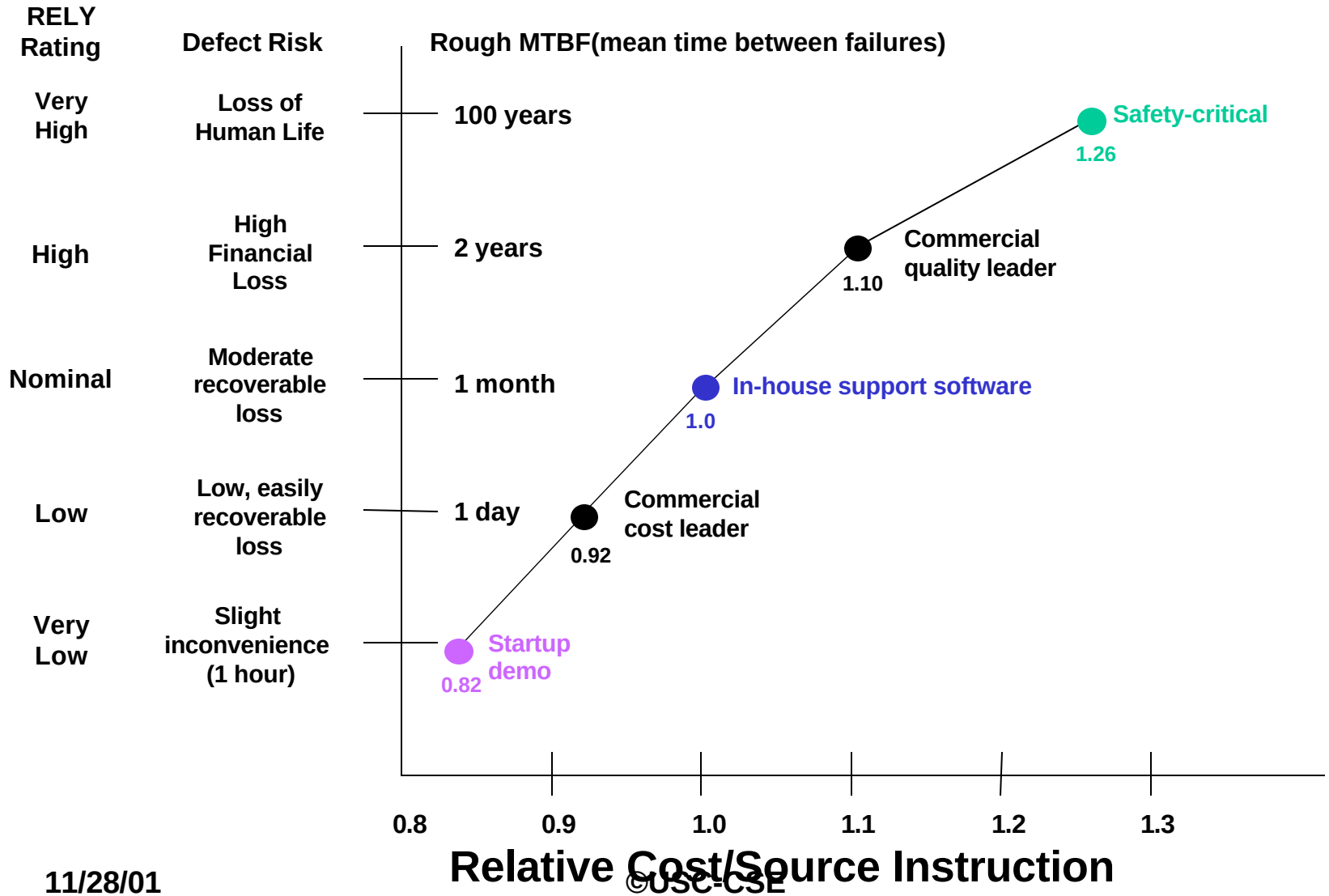


# Conclusions So Far

- Unwise to try to compete on both cost/schedule and quality
  - Some exceptions: major technology or marketplace edge
- There are no one-size-fits-all cost/schedule/quality strategies
- Risk analysis helps determine how much testing (prototyping, formal verification, etc.) is enough
  - Buying information to reduce risk
- Often difficult to determine parameter values
  - Some COCOMO II values discussed next

# Software Development Cost/Quality Tradeoff

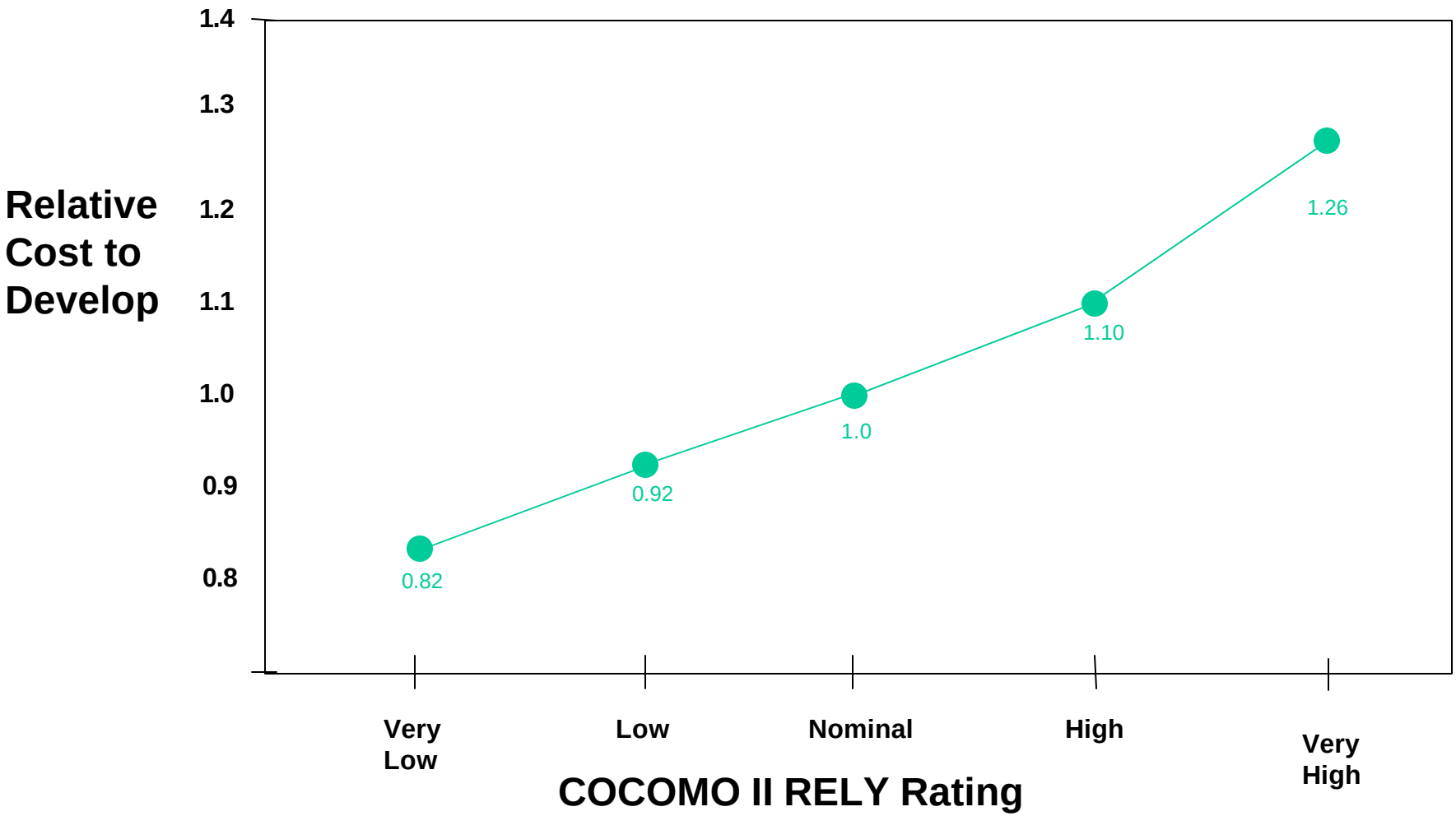
## - COCOMO II calibration to 161 projects



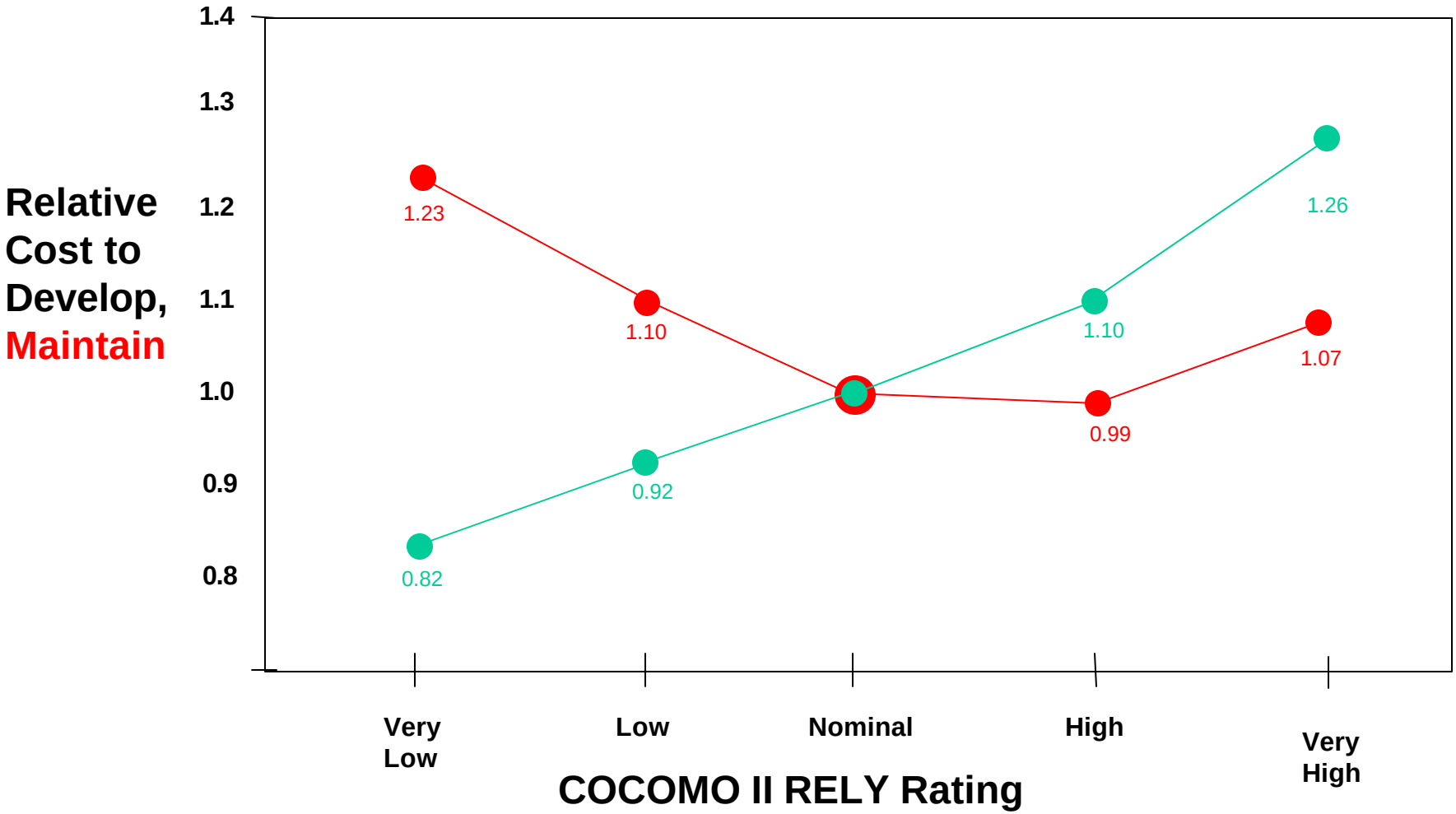
# "Quality is Free"

- Did Philip Crosby's book get it all wrong?
- Investments in dependable systems
  - Cost extra for simple, short-life systems
  - Pay off for high-value, long-life systems

# Software Life-Cycle Cost vs. Dependability



# Software Life-Cycle Cost vs. Dependability



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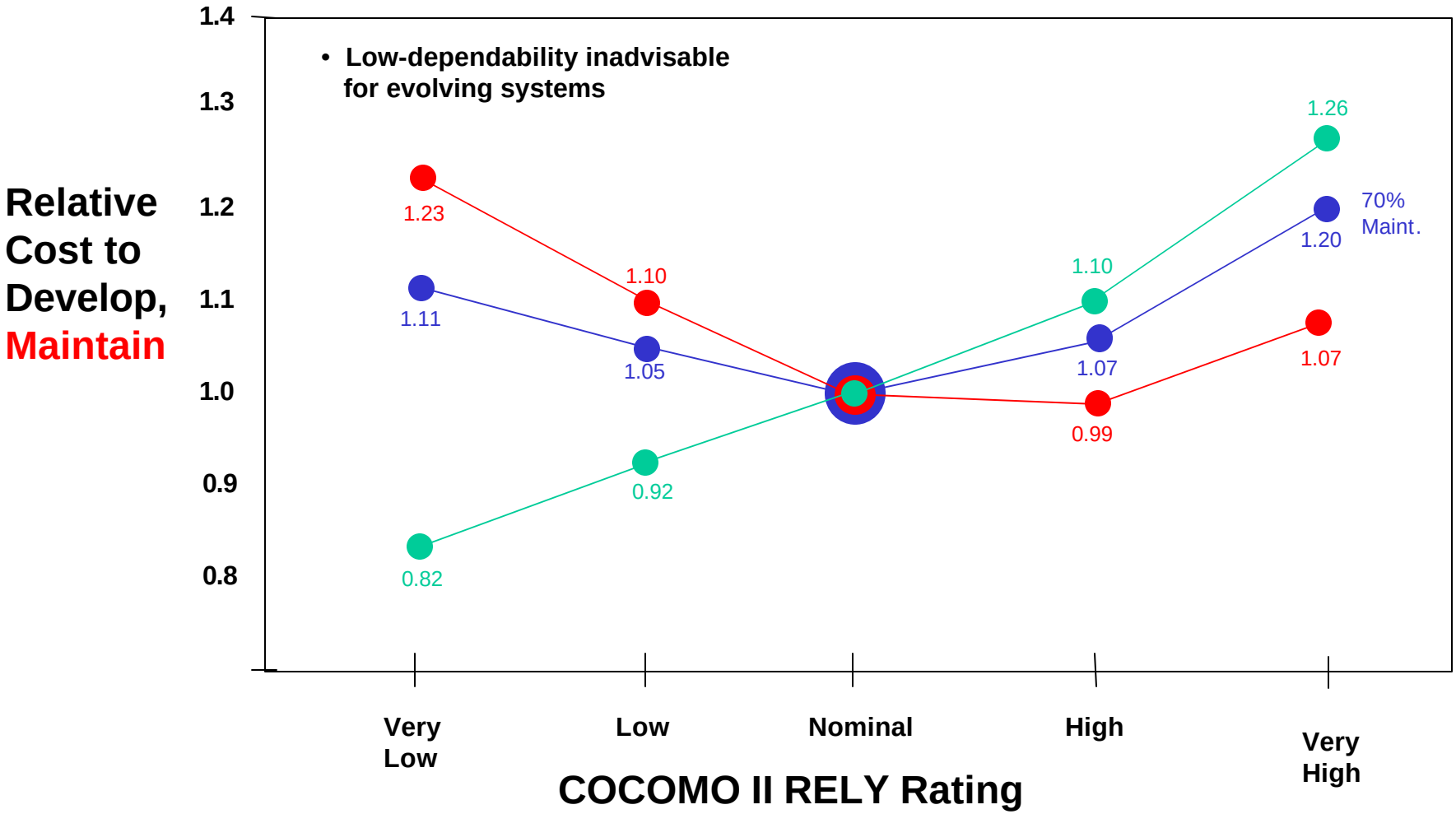
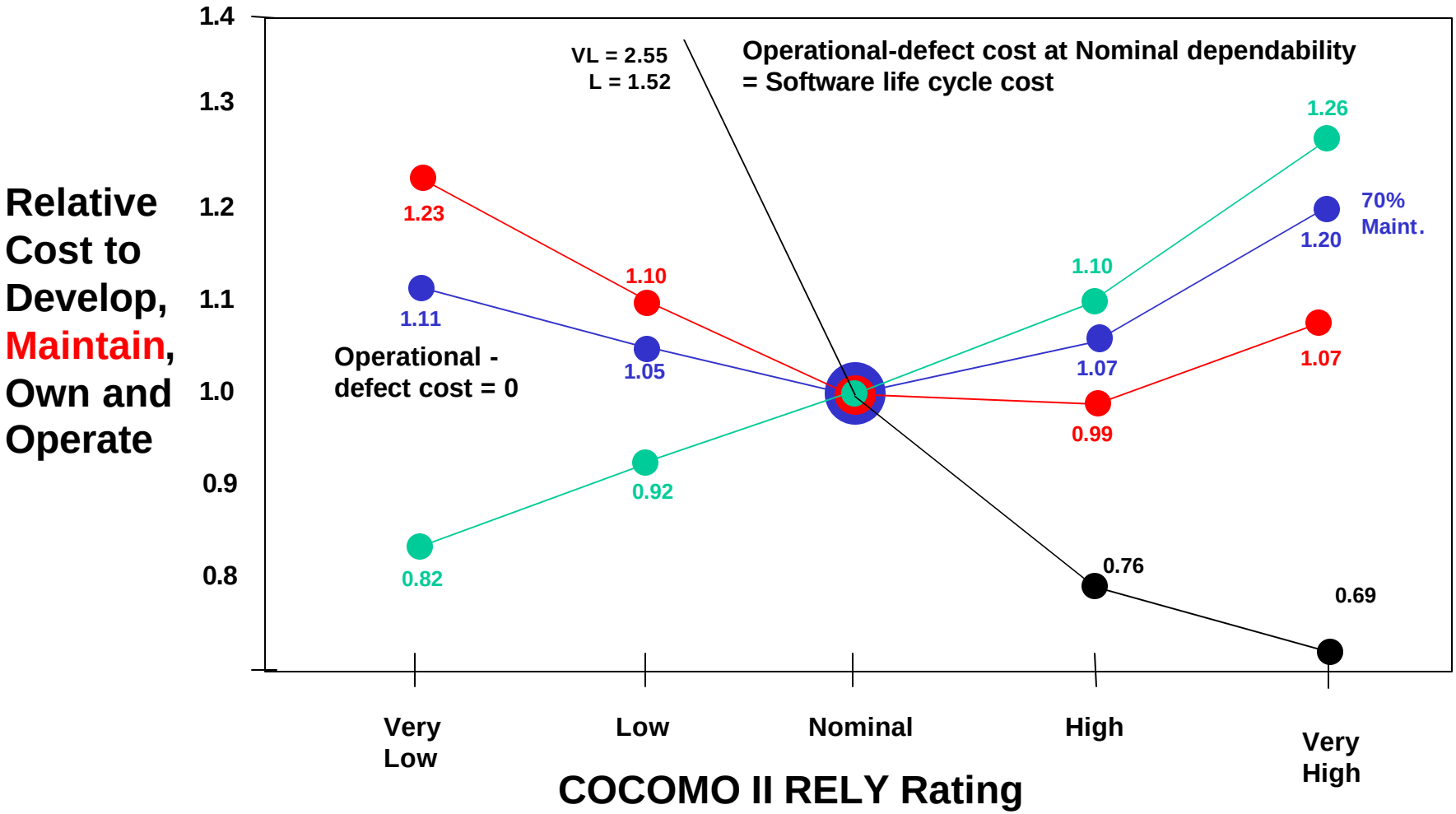


# Software Ownership Cost vs. Dependability



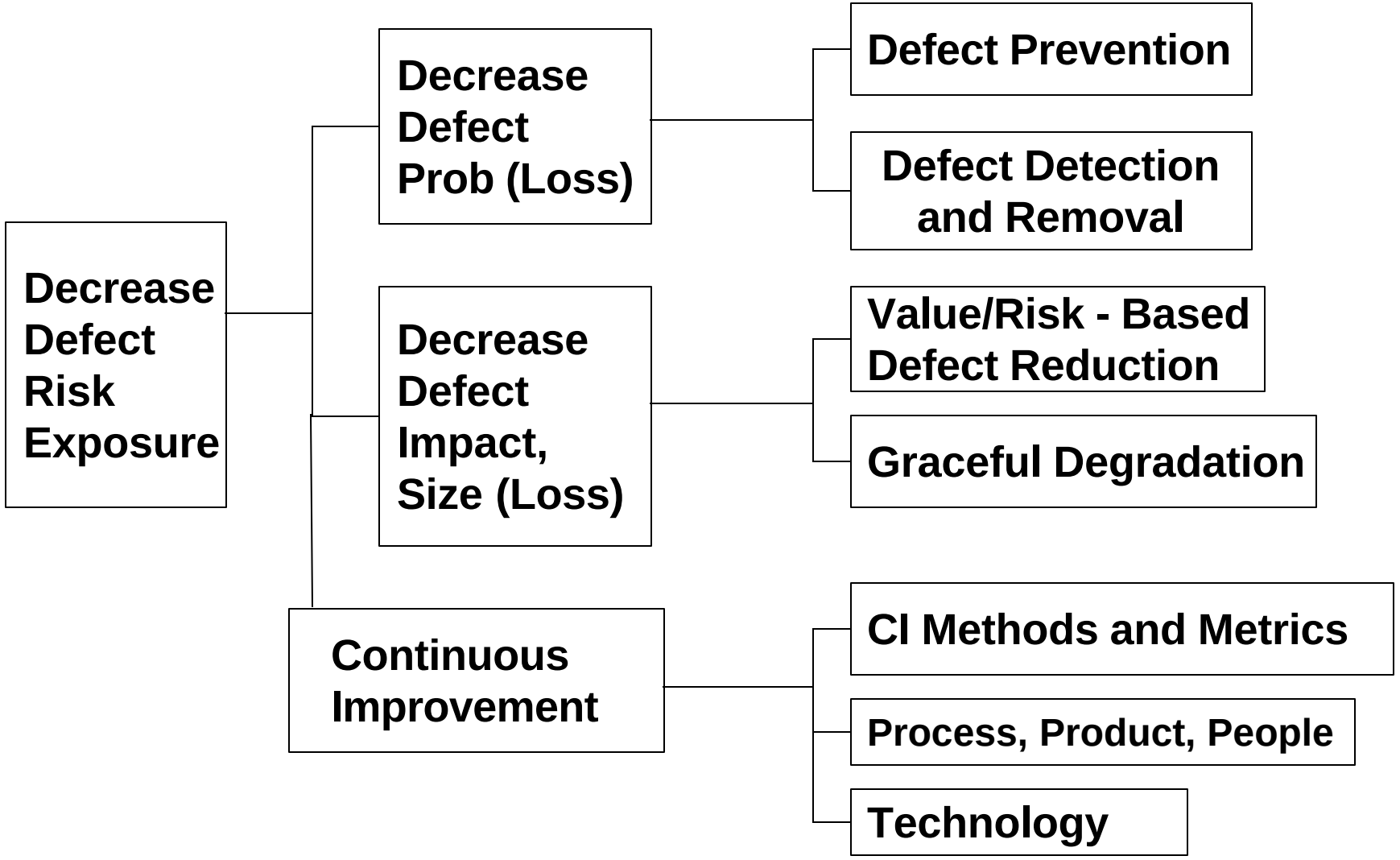
# Conclusions So Far - 2

- Quality is better than free for high-value, long-life systems
- There is no universal dependability sweet spot
  - Yours will be determined by your value model
  - And the relative contributions of dependability techniques
    - Let's look at these next

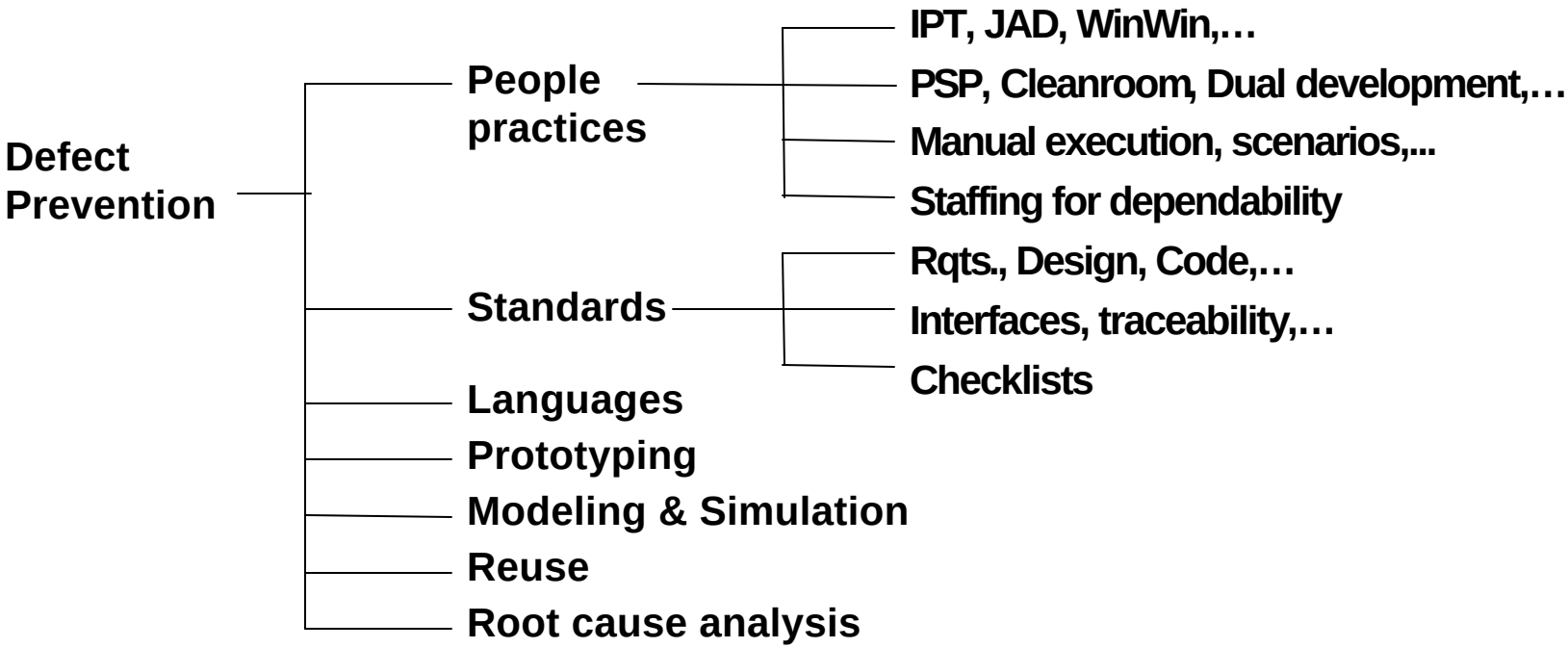
# HDC in a Competitive World

- The economics of IT competition and dependability
- Software Dependability Opportunity Tree
  - Decreasing defects
  - Decreasing defect impact
  - Continuous improvement
- Conclusions

# Software Dependability Opportunity Tree



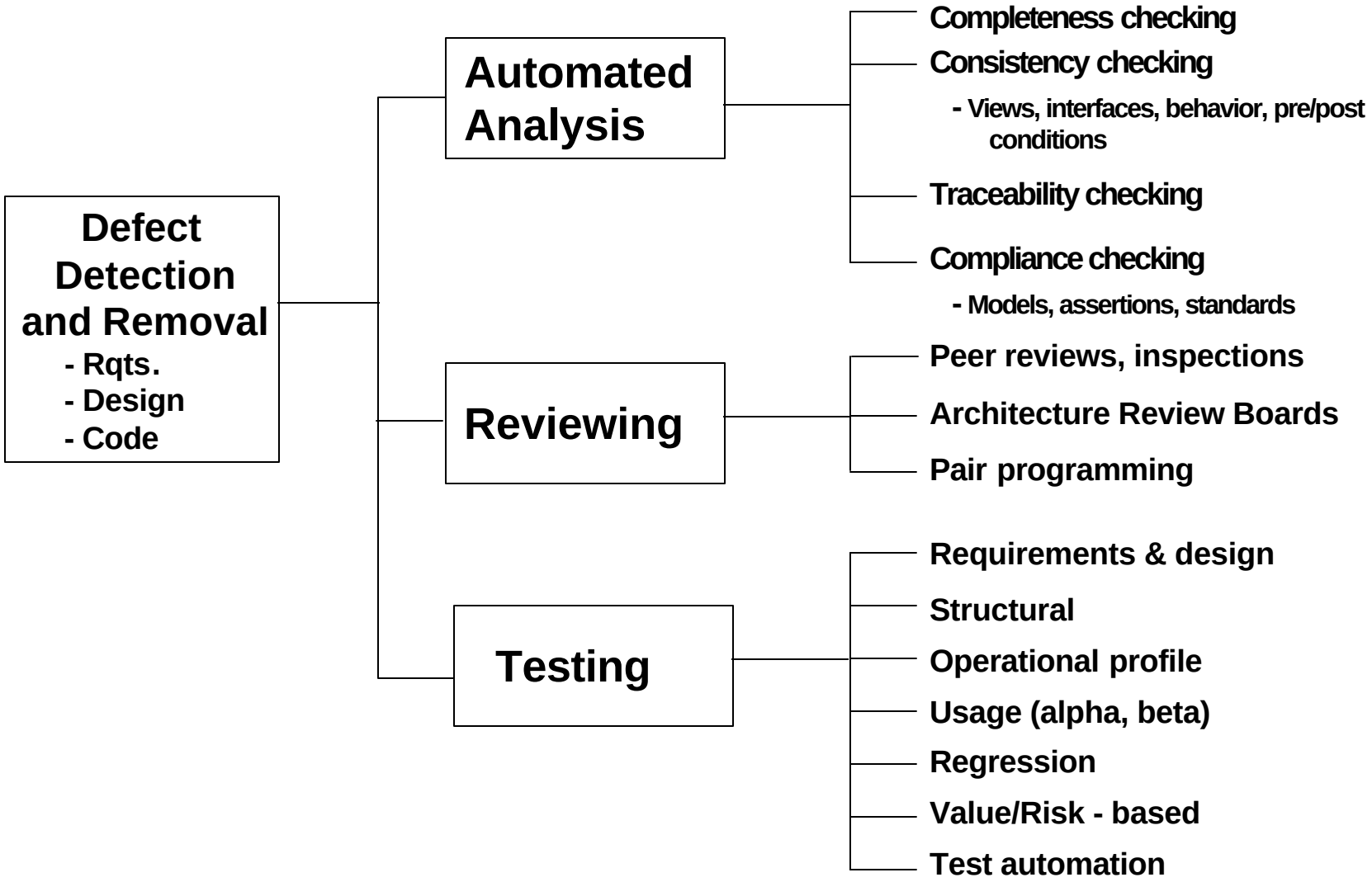
# Software Defect Prevention Opportunity Tree



# People Practices: Some Empirical Data

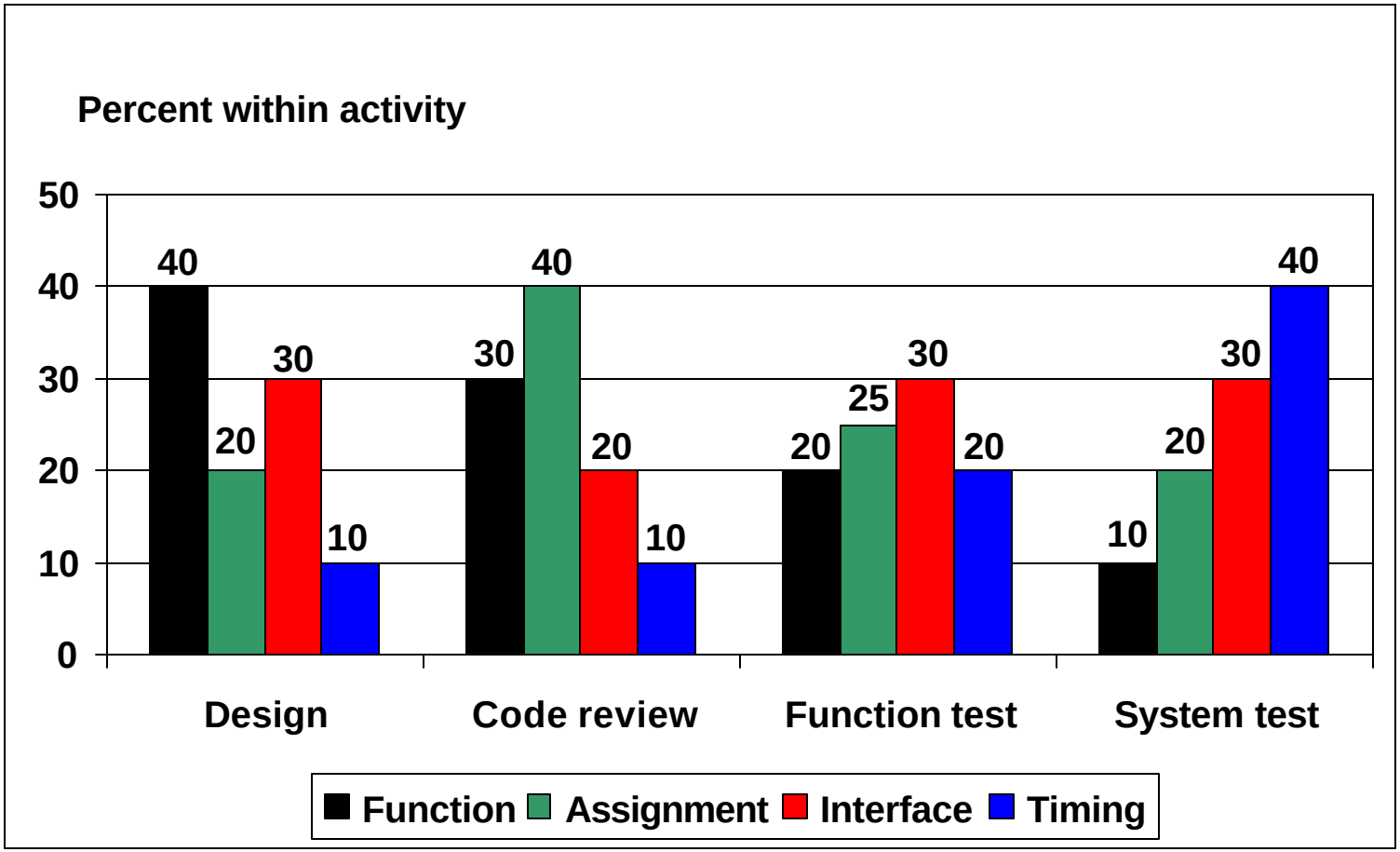
- Cleanroom: Software Engineering Lab
  - 25-75% reduction in failure rates
  - 5% vs 60% of fix efforts over 1 hour
- Personal Software Process/Team Software Process
  - 50-75% defect reduction in CMM Level 5 organization
  - Even higher reductions for less mature organizations
- Staffing
  - Many experiments find factor-of-10 differences in people's defect rates

# Software Defect Detection Opportunity Tree

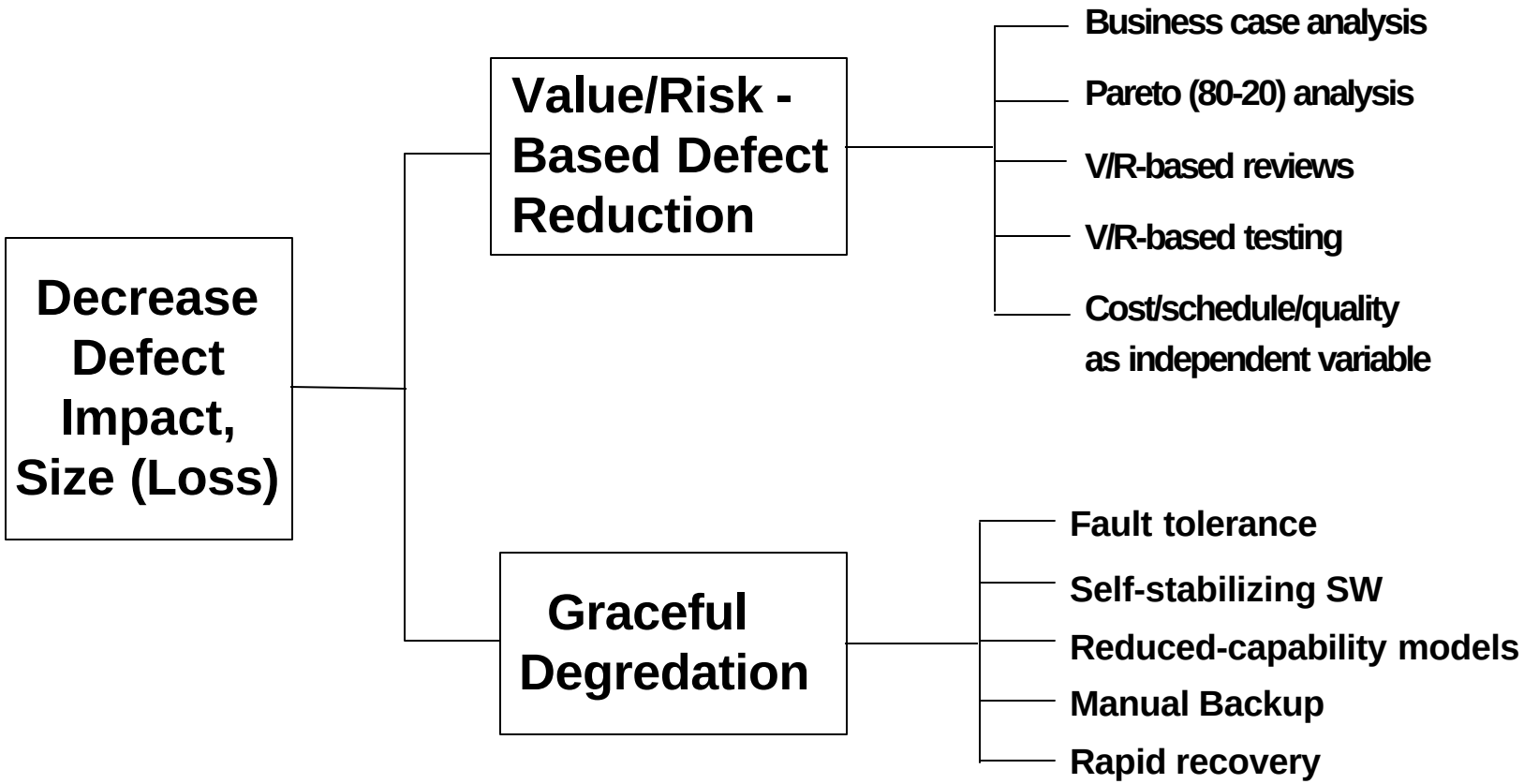


# Orthogonal Defect Classification

## - Chillarege, 1996



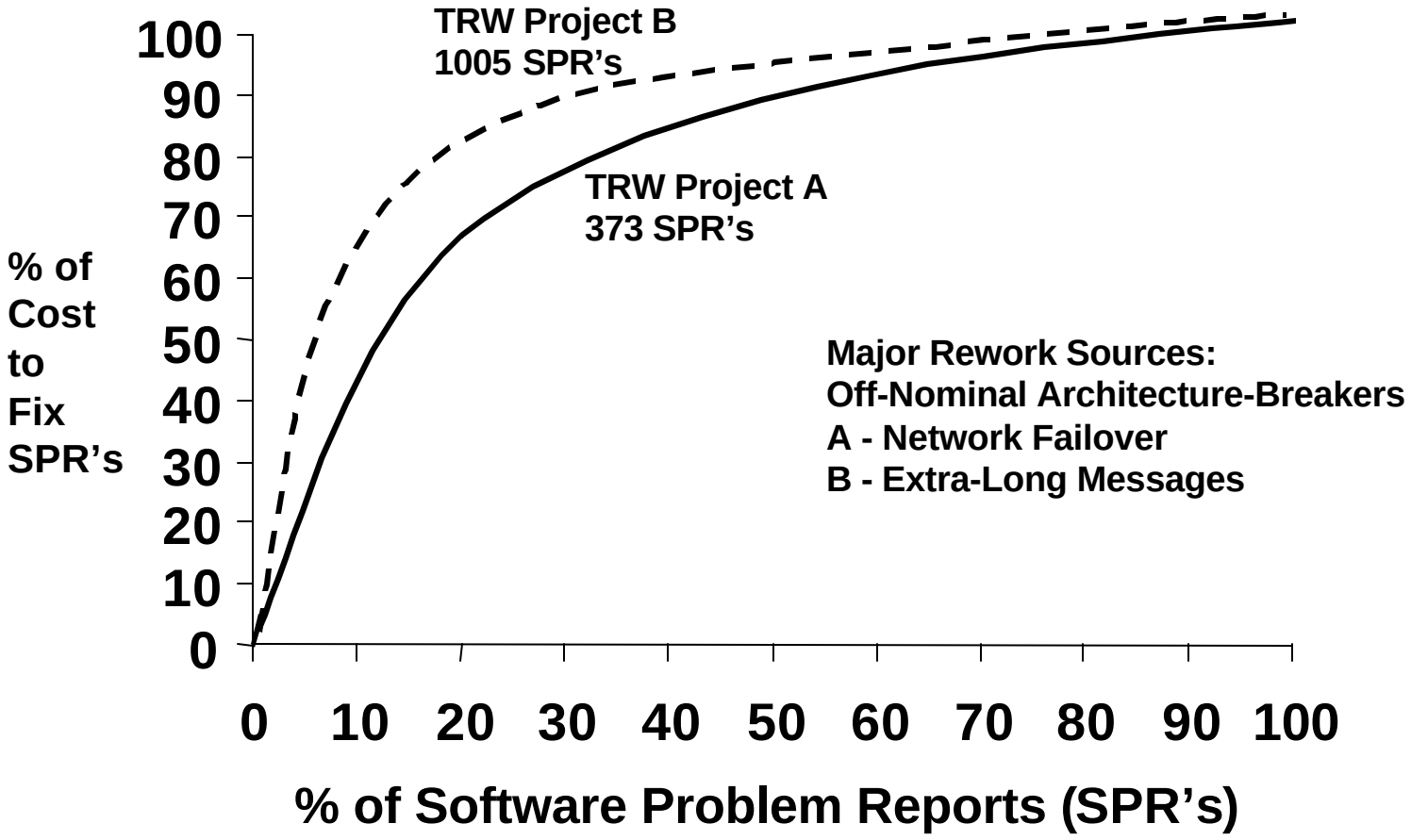
# Defect Impact Reduction Opportunity Tree



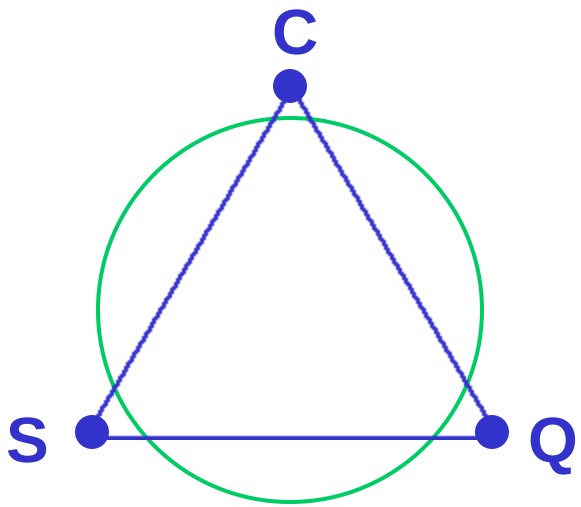
# Pareto 80-20 Phenomena

- 80% of the rework comes from 20% of the defects
- 80% of the defects come from 20% of the modules
  - About half the modules are defect-free
- 90% of the downtime comes from < 10% of the defects

# Pareto Analysis of Rework Costs

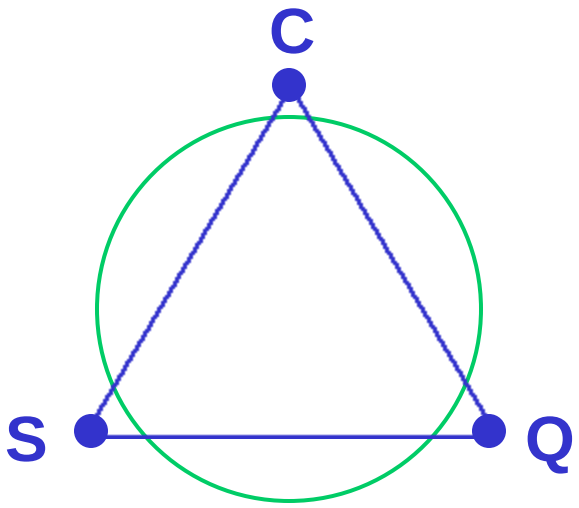


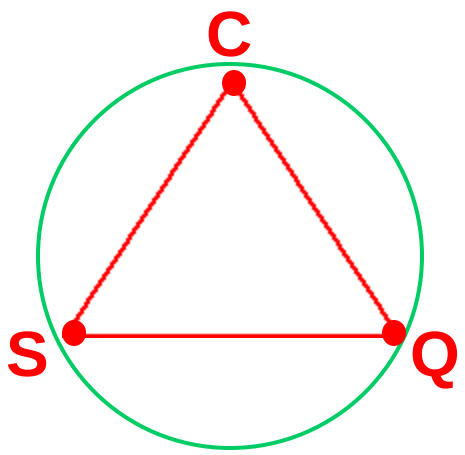
# Cost, Schedule, Quality: Pick any Two?



# Cost, Schedule, Quality: Pick any Two?

- Consider C, S, Q as Independent Variable
  - Feature Set as Dependent Variable



# C, S, Q as Independent Variable

- Determine Desired Delivered Defect Density (D4)
  - Or a value-based equivalent
- Prioritize desired features
  - Via QFD, IPT, stakeholder win-win
- Determine Core Capability
  - 90% confidence of D4 within cost and schedule
  - Balance parametric models and expert judgment
- Architect for ease of adding next-priority features
  - Hide sources of change within modules (Parnas)
- Develop core capability to D4 quality level
  - Usually in less than available cost and schedule
- Add next priority features as resources permit
- Versions used successfully on 17 of 19 USC digital library projects

# Conclusions

- Future trends intensify competitive HDC challenges
  - Complexity, criticality, decreased control, faster change
- Organizations need tailored, mixed HDC strategies
  - No universal HDC sweet spot
  - Goal/value/risk analysis useful
  - Quantitative data and models becoming available
- HDC Opportunity Tree helps sort out mixed strategies
- Quality is better than free for high-value, long-life systems
- Attractive new HDC technology prospects emerging
  - Architecture- and model-based methods
  - Lightweight formal methods
  - Self-stabilizing software
  - Complementary theory and empirical methods

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# CeBASE Software Defect Reduction Top-10 List - http://www.cebase.org

1. Finding and fixing a software problem after delivery is often 100 times more expensive than finding and fixing it during the requirements and design phase.
2. About 40-50% of the effort on current software projects is spent on avoidable rework.
3. About 80% of the avoidable rework comes form 20% of the defects.
4. About 80% of the defects come from 20% of the modules and about half the modules are defect free.
5. About 90% of the downtime comes from at most 10% of the defects.
6. Peer reviews catch 60% of the defects.
7. Perspective-based reviews catch 35% more defects than non-directed reviews.
8. Disciplined personal practices can reduce defect introduction rates by up to 75%.
9. All other things being equal, it costs 50% more per source instruction to develop high-dependability software products than to develop low-dependability software products. However, the investment is more than worth it if significant operations and maintenance costs are involved.
10. About 40-50% of user programs have nontrivial defects.